Appendicitis:
Updates and Current Trends in Management

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University of California, Los Angeles
Disclosures

• None
Goals

• Review epidemiology and initial assessment

• Address surgical controversies

• Discuss current management options
Appendicitis

• “Appendicitis is the most common condition in children requiring emergency abdominal surgery”

• “The key to a successful outcome is early diagnosis followed by appendectomy before gangrene or perforation develops”
Epidemiology

• Lifetime risk 8%
  • Peak incidence 4-14 years old
  • <5% of patients under 5
    • <50% advanced disease vs ~20%

• 70,000 children annually in the US
  • 11.4% of all pediatric ER visits

• 60,000-80,000 pediatric appendectomies annually
Etiology

• Luminal obstruction
  • Fecalith or lymphatic tissue
  • Impairment of venous return
  • Initial distention causing diffuse pain
  • Inflammation of serosa causing RLQ pain
  • Perforation
Presentation

- Difficulty walking - 82%
- Maximum tenderness in RLQ - 82%
- Nausea - 79%
- Pain with percussion, hopping, or coughing - 79%
- Anorexia - 75-95%
- Vomiting - 66%
- Fever - 47%
- Diarrhea - 16%
Clinical Presentation

• Periumbilical pain then localized pain in right lower quadrant
• Pain is constant and worsening for more than 24 hours
• Anorexia, Nausea, +/- vomiting
• +/- Fever/Diarrhea
• +/- Diarrhea
• Most tender in right lower quadrant
• +/- guarding, rebound
• Rovsing sign, Psoas sign, Obturator sign

*History and Exam is much less reliable in children < 5y/o*
Physical exam

- Administration of analgesics DOES NOT impact the ability to make a diagnosis of appendicitis

- Localized peritonitis in the right lower quadrant
  - Consider variants in anatomy (retrocecal, pelvic, malrotation)
  - Advanced appendicitis and/or young age
Diagnostics

• Labarotory testing
  • CBC, ANC have variable sensitivity and specificity (60’s-90’s)

• CRP and Procalcitonin- may be useful in identifying perforation

• UA- Patients with appendicitis may have pyuria and hematuria
Scoring System

- **Low Risk**
  - $\leq 3 = 0$ to $2\%$

- **Intermediate Risk**
  - $3 - 6 = 8$-48%

- **High Risk**
  - $\geq 7 = 78$-96%

### The Pediatric Appendicitis Score

<table>
<thead>
<tr>
<th>Item</th>
<th>Score (point)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anorexia</td>
<td>1</td>
</tr>
<tr>
<td>Nausea or vomiting</td>
<td>1</td>
</tr>
<tr>
<td>Migration of pain</td>
<td>1</td>
</tr>
<tr>
<td>Fever $&gt;38^\circ$C (100.5$^\circ$F)</td>
<td>1</td>
</tr>
<tr>
<td>Pain with cough, percussion or hopping</td>
<td>2</td>
</tr>
<tr>
<td>Right lower quadrant tenderness</td>
<td>2</td>
</tr>
<tr>
<td>White blood cell count $&gt;10,000$ cells/µL</td>
<td>1</td>
</tr>
<tr>
<td>Neutrophils plus band forms $&gt;7500$ cells/µL</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10 points</strong></td>
</tr>
</tbody>
</table>

C: Centigrade; F: Fahrenheit.
Imaging

- Plain x-rays
- Contrast enema
- ULTRASONOGRAPHY
- COMPUTERIZED TOMOGRAPHY
- MRI
Ultrasonography

- When appendix is visualized
  - As good as CT (sens/spec 98 and 92%)

- Appendix not seen 22-98%
  - Lower sensitivity and specificity
  - Non visualization correlated with operator experience and obesity
CT

• Advantages
  • Sensitivity - 94-100%
  • Specificity - 93-100%
  • Not operator dependent
  • May identify alternative causes of pain

• Disadvantages
  • Ionizing radiation
  • More time consuming
  • Contrast related complications
  • Cost
CT techniques

- **PO contrast**
  - Does not improve sensitivity and specificity
  - Delays study by ~2 hours
  - Contrast not in cecum at the time of study ~30% of the time
  - May require NG placement

- **Rectal contrast**
  - Difficult/uncomfortable to administer
  - Contraindicated with perforation
  - No advantage

- **IV contrast**
  - Increases sensitivity of study (particularly <10 years old)
  - Prevents repeat scanning if initial study negative
  - Contrast hypersensitivity unlikely in children

- **Focused scanning**
  - Lower pole of kidney to pubis
MRI

- Limitations
  - Availability
  - Longer procedure time
    - >20 mins
  - Experience with interpretation
- May be done without contrast
Practically Speaking......
Non visualized appendix on ultrasound

• Low Risk
  • Observation and serial exams
  • Home, ED, Admit

• Intermediate Risk
  • Observe (in house)
  • CT
  • Obtain surgical consultation

• High Risk
  • Obtain surgical consultation
Diagnostic approach to pediatric appendicitis

Clear alternative diagnosis, for example:
* Streptococcal pharyngitis
* Pneumonia
* Pelvic inflammatory disease

Treat underlying condition

High risk:
* Classic physical findings of appendicitis* (PAS ≥ 7 or greater)
* Elevated WBC, ANC, and/or CRP

Prompt surgical consultation is suggested prior to ordering urgent imaging

Moderate risk:
* Some findings of appendicitis (PAS ≥ 3 to 6)
* WBC, ANC, and/or CRP normal or elevated

Antibiotics given prior to evaluation?

Diagnostic imaging?

Diagnostic imaging positive or not definitive?

Surgical consultation

RLQ pain or tenderness present?

Reevaluate in 12 to 24 hours OR Admit patient for serial examinations

Discharge home with instruction to return if pain increases or localizes to the RLQ

PAS = Pediatric Appendicitis Score, WBC = white blood count, ANC = absolute neutrophil count, CRP = C-reactive protein.
 Management

Appendicitis

Non-perforated

Perforation

Early

Abscess of Phlegmon

• Bowel Rest
• Fluid Resuscitation
• Antibiotics
• Pain Control
• Surgical Consultation
Acute Uncomplicated Appendicitis—Appendectomy

• Laparoscopic vs. Open vs. Trans-umbilical vs. Single Incision!
Acute Uncomplicated Appendicitis - Appendectomy

- **Commonalities (good)**
  - Curative
  - Allows pathologic examination

- **Commonalities (bad)**
  - General anesthesia
  - Associated morbidity and mortality
    - Infection
    - Iatrogenic injuries
    - Bowel obstruction
    - Incisions (hernia, scar)
  - Pain
Laparoscopic vs. Open Approach

- **Laparoscopy**
  - Shorter length of stay
  - Less wound infections
  - Pain
  - Return to full activity
  - **Same day discharge?**
  - Cosmesis?

- **Open**
  - Shorter operative time (7-11 minutes)
  - Less intra-abdominal abscesses in perforated appendicitis
  - Less Cost
    - $4734 (±$2199) for open
    - $5935 lap in 1992
    - $3718 lap in 2004

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*Laparoscopic versus open appendectomy in children: a meta-analysis.*

*Laparoscopic versus open appendectomy for complicated and uncomplicated appendicitis in children.*

Timing of operation

“The key to a successful outcome is early diagnosis followed by PROMPT appendectomy before gangrene or perforation develops”

- Washington state database
- 9,048 adults
  - Negative appy’s excluded
- 15.8% perforated
- Mean time to OR = 6.8 hours
  - Same for perforated and non
- Multivariate analyses showed no increase in perforation rate with increasing time AFTER PRESENTATION
Timing of operation

“The key to a successful outcome is early diagnosis followed by PROMPT appendectomy before gangrene or perforation develops”

- Retrospective cohort study
- 484 non-perforated pts
  - Time from admission to the OR did not predict perforation
- Surgical site infections, perforations, and small bowel obstructions were similar between groups

<table>
<thead>
<tr>
<th>Complications</th>
<th>Total (n=484)</th>
<th>Admission to OR at &lt;6 h</th>
<th>Admission to OR at &gt;6 h</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>SSI, n (%)</td>
<td>13 (2.7)</td>
<td>8 (3.1)</td>
<td>5 (2.3)</td>
<td>0.794</td>
</tr>
<tr>
<td>Wound infection</td>
<td>5 (1.0)</td>
<td>3 (1.1)</td>
<td>2 (0.9)</td>
<td>0.791</td>
</tr>
<tr>
<td>Intra-abdominal abscess</td>
<td>8 (1.7)</td>
<td>5 (1.9)</td>
<td>3 (1.4)</td>
<td>0.904</td>
</tr>
<tr>
<td>Perforation</td>
<td>109 (22.5)</td>
<td>54 (20.6)</td>
<td>55 (24.8)</td>
<td>0.325</td>
</tr>
<tr>
<td>Small bowel obstruction</td>
<td>1 (0.2)</td>
<td>0 (0)</td>
<td>1 (0.5)</td>
<td>0.934</td>
</tr>
</tbody>
</table>

OR = operating room; SSI = surgical site infection.

Optimal timing of appendectomy in the pediatric population.
Gurien LA1, Wyrick DL2, Smith SB2, Dassinger MS2.
Timing of operation

“The key to a successful outcome is early diagnosis followed by PROMPT appendectomy before gangrene or perforation develops”

- Retrospective study
- 192 patients
  - Adults and children
- Looked at overall time, prehospital time, and in-hospital time
- No difference in complications (wound infection or postoperative pericecal inflammation)
Usual Course

• Diagnosis of appendicitis with attempt to avoid CT
• Initiation of antibiotics
• Proceed to OR in semi-elective fashion
• Laparoscopic vs. open approach based on surgeon preference
• Same day vs. next day discharge
• No post-operative antibiotics
• Minimal activity restrictions
“Appendicitis is the most common condition in children requiring emergency abdominal surgery.”
## Non-operative Treatments

### Table 4. Epidemiology of Appendicitis

<table>
<thead>
<tr>
<th>First author</th>
<th>Population</th>
<th>Years</th>
<th>Incidence</th>
<th>Success rate of nonoperative treatment (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice²³</td>
<td>US subs</td>
<td>1941–1945</td>
<td>—</td>
<td>88.9</td>
</tr>
<tr>
<td>Rice²³</td>
<td>US subs</td>
<td>1960–1964</td>
<td>—</td>
<td>86.6</td>
</tr>
<tr>
<td>Wilken²⁵</td>
<td>US subs</td>
<td>1963–1967</td>
<td>9.9</td>
<td>84.4</td>
</tr>
<tr>
<td>Glover²⁷</td>
<td>UK subs</td>
<td>1968–1978</td>
<td>25.5</td>
<td>95.0</td>
</tr>
</tbody>
</table>

### Table 3. Nonoperative Treatment of Appendicitis

<table>
<thead>
<tr>
<th>First author</th>
<th>Year</th>
<th>n</th>
<th>Success rate of nonoperative treatment (%)</th>
<th>Longterm rate of recurrence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oliak¹⁵</td>
<td>2001</td>
<td>88</td>
<td>94.2</td>
<td>8</td>
</tr>
<tr>
<td>Vargas¹⁶</td>
<td>1994</td>
<td>12</td>
<td>100.0</td>
<td>—</td>
</tr>
<tr>
<td>Hofmann¹⁷</td>
<td>1984</td>
<td>44</td>
<td>—</td>
<td>20</td>
</tr>
<tr>
<td>Skoubo-Kristensen¹⁸</td>
<td>1982</td>
<td>193</td>
<td>88.0</td>
<td>—</td>
</tr>
<tr>
<td>Paul¹⁹</td>
<td>1982</td>
<td>42</td>
<td>—</td>
<td>5</td>
</tr>
<tr>
<td>Cobben¹⁰</td>
<td>2000</td>
<td>60</td>
<td>—</td>
<td>38</td>
</tr>
<tr>
<td>Erickson¹¹</td>
<td>1998</td>
<td>19</td>
<td>95.0</td>
<td>—</td>
</tr>
<tr>
<td>Gurin⁷</td>
<td>1995</td>
<td>252</td>
<td>94.1</td>
<td>—</td>
</tr>
<tr>
<td>Harrison⁷</td>
<td>1953</td>
<td>47</td>
<td>89.5</td>
<td>—</td>
</tr>
<tr>
<td>Coldrey⁸</td>
<td>1959</td>
<td>471</td>
<td>89.8</td>
<td>—</td>
</tr>
</tbody>
</table>


Nonoperative treatment of suspected appendicitis in remote medical care environments: implications for future spaceflight medical care.

Campbell MJ¹, Johnston SL 3rd, Marshburn T, Kane J, Lupp D.
Non Operative Treatment in Adults

Randomised to antibiotic treatment (n=470)
- Protocol violations excluded from analysis (n=32)
  - Antibiotic treatment (n=438)
    - Successful initial treatment with antibiotics (n=345, 78%)
      - Readmissions (n=68, 20%)
        - Successful treatment with antibiotics (n=3)
      - No further symptoms at one year (n=277, 63%)
    - Crossover to surgery (n=93, 21%)
      - Surgery for failed antibiotic treatment (n=29)
      - (Hansson et al) Surgery for other reasons
        - Specified clinical judgment (n=19)
        - Unspecified clinical judgment (n=45)
      - Histology available (n=11)
    - Appendicitis (n=36)
      - Appendicectomy (n=65)
        - Phlegmonous (n=48)
          - Perforated (n=9)
        - Gangrenous (n=4)
          - Normal appendix (n=4)
      - Other diagnosis (n=4)
        - Terminal ileitis (n=1)
          - Surgically treatable (n=1)
        - Normal appendix (n=2)

BMJ. 2012 Apr 5;344:e2156. doi: 10.1136/bmj.e2156.

Safety and efficacy of antibiotics compared with appendicectomy for treatment of uncomplicated acute appendicitis: meta-analysis of randomised controlled trials.

Venturini KK, Neel KR, Lobo DN.
Non Operative Treatment in Adults

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Antibiotic treatment</th>
<th>Appendicectomy</th>
<th>Mean difference (inverse variance, random) (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All studies</td>
<td>Mean (SD)/total</td>
<td>Mean (SD)/total</td>
<td>Weight (%)</td>
</tr>
<tr>
<td>Vons 2011</td>
<td>3.96 (4.87)/120</td>
<td>3.04 (1.5)/119</td>
<td>11.5 0.92 (0.01 to 1.83)</td>
</tr>
<tr>
<td>Hansson 2009</td>
<td>3 (0.1)/202</td>
<td>3 (0.3)/167</td>
<td>43.3 0.00 (-0.05 to 0.05)</td>
</tr>
<tr>
<td>Styrud 2006</td>
<td>3 (1.4)/128</td>
<td>2.6 (1.2)/124</td>
<td>32.4 0.40 (0.08 to 0.72)</td>
</tr>
<tr>
<td>Eriksson 1995</td>
<td>3.1 (0.3)/20</td>
<td>3.4 (1.9)/20</td>
<td>12.9 -0.30 (-0.16 to 0.56)</td>
</tr>
<tr>
<td>Subtotal</td>
<td>470</td>
<td>430</td>
<td>100.0 0.20 (-0.16 to 0.56)</td>
</tr>
</tbody>
</table>
| Test for heterogeneity: \( \chi^2 = 10.16, df = 3, P = 0.02, I^2 = 70\% \)
| Test for overall effect: \( z = 1.07, P = 0.29 \)

<table>
<thead>
<tr>
<th>Studies with no crossover of patients</th>
<th>Antibiotic treatment</th>
<th>Appendicectomy</th>
<th>Mean difference (inverse variance, random) (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Styrud 2006</td>
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<td>2.6 (1.2)/124</td>
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</tr>
<tr>
<td>Eriksson 1995</td>
<td>3.1 (0.3)/20</td>
<td>3.4 (1.9)/20</td>
<td>24.7 -0.30 (-0.19 to 0.87)</td>
</tr>
<tr>
<td>Subtotal</td>
<td>268</td>
<td>263</td>
<td>100.0 0.34 (-0.19 to 0.87)</td>
</tr>
</tbody>
</table>
| Test for heterogeneity: \( \chi^2 = 3.86, df = 2, P = 0.38 \)

*Fig 5. Antibiotic therapy versus appendicectomy for uncomplicated appendicitis: forest plot for length of primary hospital stay.*
## Surgery vs. Abx: RCTs

<table>
<thead>
<tr>
<th></th>
<th>Erriksson</th>
<th>Styrud</th>
<th>Turhan</th>
<th>Hansson</th>
<th>Vons</th>
<th>Salminen</th>
<th>Svensson</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year</strong></td>
<td>92-94</td>
<td>96-99</td>
<td>05-06</td>
<td>06-07</td>
<td>04-07</td>
<td>09-12</td>
<td>12-13</td>
</tr>
<tr>
<td><strong>Country</strong></td>
<td>🇸🇪</td>
<td>🇸🇪</td>
<td>🇹🇷</td>
<td>🇸🇪</td>
<td>🇫🇷</td>
<td>🇫🇮</td>
<td>🇸🇪</td>
</tr>
<tr>
<td><strong>Age - range (ave)</strong></td>
<td>18-75(32)</td>
<td>18-50</td>
<td>13-65(28)</td>
<td>&gt;18(38)</td>
<td>18-68(36)</td>
<td>26-47(34)</td>
<td>5-15(12)</td>
</tr>
<tr>
<td><strong>Imaging (%)</strong></td>
<td>100(us)</td>
<td>0</td>
<td>100(ct)</td>
<td>24-31(us/ct)</td>
<td>100(ct)</td>
<td>100(ct)</td>
<td>100(us/ct)</td>
</tr>
<tr>
<td><strong>Laparoscopic (%)</strong></td>
<td>NR</td>
<td>6</td>
<td>82</td>
<td>NR</td>
<td>66</td>
<td>5.5</td>
<td>100</td>
</tr>
<tr>
<td><strong>Follow-up (d)</strong></td>
<td>30</td>
<td>365</td>
<td>365</td>
<td>365</td>
<td>365</td>
<td>365</td>
<td>365</td>
</tr>
<tr>
<td><strong>Abx-surgery (%)</strong></td>
<td>38</td>
<td>24</td>
<td>18</td>
<td>22</td>
<td>28</td>
<td>27</td>
<td>8</td>
</tr>
</tbody>
</table>
Prospective Trial

- Prospective nonrandomized trial
- 30 non op (patient/family choice) and 47 surgery
- 90% success of non-op at 30 days

### Comparison of Outcomes at 30-Day Follow-Up

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Nonoperative management (n = 28)</th>
<th>Surgery (n = 38)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of stay, h, median (IQR)</td>
<td>36.0 (31.0–42.0)</td>
<td>20.0 (16.0–34.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Days to return to normal activities, median (IQR)</td>
<td>3.0 (2.5–6.5)</td>
<td>16.5 (9.0–21.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Days of school missed, median (IQR)</td>
<td>3.0 (2.0–5.0)</td>
<td>5.0 (3.0–6.0)</td>
<td>0.008</td>
</tr>
<tr>
<td>Days for guardian to return to normal schedule, median (IQR)</td>
<td>2.0 (1.0–3.0)</td>
<td>3.0 (1.0–6.0)</td>
<td>0.12</td>
</tr>
<tr>
<td>Fevers, n (%)</td>
<td>2 (7.1)</td>
<td>4 (10.5)</td>
<td>1.00</td>
</tr>
<tr>
<td>Abdominal pain, n (%)</td>
<td>6 (21.4)</td>
<td>12 (31.6)</td>
<td>0.36</td>
</tr>
<tr>
<td>Nausea, n (%)</td>
<td>1 (3.6)</td>
<td>3 (7.9)</td>
<td>0.63</td>
</tr>
<tr>
<td>Vomiting, n (%)</td>
<td>3 (10.7)</td>
<td>3 (7.9)</td>
<td>0.69</td>
</tr>
<tr>
<td>Patients with an ED visit at 30 d, n (%)</td>
<td>2 (7.14)</td>
<td>4 (10.5)</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Randomized Pilot Study

- Prospective randomized study
- 2 of 24 patients in non-op group underwent surgery within 90d
  - 1 negative appy
  - 1 perforated appy
- At 1 year f/u, 15/24 patients had not undergone appendectomy
  - Only 1 with recurrence
- 5 pts in antibiotic group had fecalith
  - 2 no surgery
  - 1 recurrent appendicitis
  - 2 removed but no appendicitis

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*Nonoperative treatment with antibiotics versus surgery for acute nonperforated appendicitis in children: a pilot randomized controlled trial.*

Randomized Pilot Study

• Median time to discharge
  • Surgical group 34.5 hrs
  • Non-operative treatment group 51.5hrs ($P = 0.0004$).

• Cost for the initial inpatient stay
  • Nonoperative treatment group 30,732SEK
  • Surgery group 45,805SEK ($P < 0.0001$)

• The total cost of treatment, including the cost of those patients having an appendectomy during the follow-up period,
  • Nonoperative treatment 34,587SEK
  • Surgery 45,805 SEK ($P = 0.11$)

*Nonoperative treatment with antibiotics versus surgery for acute nonperforated appendicitis in children: a pilot randomized controlled trial.*
Longer Follow Up

- 78 patients treated with abx, followed for average of 4.3 years
  - 1 failure
  - 22 with recurrence (29%)
- Median time to recurrence was 6 months (range, 17 days–39 months)
- Recurrence rate within 1 year was 20.8% (16pts)

**Graph:**
- Number of recurrent patients over time
- X-axis: months
- Y-axis: number of recurrent patients
- Data points indicating recurrence rate over time


**Long-term outcomes of operative versus nonoperative treatment for uncomplicated appendicitis.**

Tanaka Y¹, Uchida H², Kawashima H³, Fujigl M³, Takazawa S⁴, Daie K⁴, Amano H³.
Liberalization and Fast-Tracking

• Most studies have had inclusion and exclusion restrictions
  • >5 years
  • Appendix <1.1cm
  • Symptoms less than 48hrs
  • WBC < 18k
  • +/- appendicolith
  • No evidence of perforation
  • Imaging mandatory

• UCLA experience
  • Clinical or radiologic diagnosis of appendicitis
  • Absence of diffuse peritonitis
  • Normal pregnancy test
  • No major co-morbidities
Liberalization and Fast-Tracking

• Retrospective data
  • 50 patients (56% male and 44% female) median age, 9 years [IQR 7-12 years]
  • Initially successful in 40 (80%) patients.
  • 7 (70%) failures had complicated appendicitis (5 with contained perforation and 2 with gangrenous appendicitis).
  • Recurrence rate was 13% with a median follow-up period of 305 days [125-375]
  • Median time to recurrence was 60 days [42-116].

• Overall, 34 (68%) patients avoided appendectomy.
Liberalization and Fast-Tracking

• Retrospective data
  • Patients with fecalith had a higher initial failure rate (7/19, 37%) compared to patients without (3/31, 10%; $p=0.03$).

  • The recurrence rate in patients with an appendicolith (2/12, 17%) was the same (3/28, 11%; $p=0.61$).
Liberalization and Fast-Tracking

- Prospective data
- Overall, 58% of patients treated non-operatively

<table>
<thead>
<tr>
<th></th>
<th>NOM (n=26)</th>
<th>Appendectomy (n=12)</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Days of Hospitalization</strong></td>
<td>2 [1,2]</td>
<td>1 [1,4]</td>
<td>0.65</td>
</tr>
<tr>
<td><strong>Days to Normal Activity</strong></td>
<td>3 [2,4]</td>
<td>5 [3,11]</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>Days of Pain Medication</strong></td>
<td>0 [0,3]</td>
<td>3 [2,13]</td>
<td>0.01</td>
</tr>
<tr>
<td>Morbidity</td>
<td>0</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td>Recurrence</td>
<td>5 (26%)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>QOL score (30 day)</td>
<td>100 [99,100]</td>
<td>100 [100]</td>
<td>0.71</td>
</tr>
<tr>
<td>Estimated Cost</td>
<td>N/A</td>
<td>$9,753</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Success (n=19) | Failure (n=7) | P**
--- | --- | ---
Age | 9 [7,11] | 10 [7,13] | 0.62
Male Sex | 13 (68%) | 4 (57%) | 0.60
Hours of Symptoms | 24 [24,48] | 48 [48,48] | 0.02
Pediatric Appendicitis Score | 7 [5,8] | 7 [5,9] | 0.55
WBC (x10³ per µL) | 14.9 [13,18.1] | 15 [7,5,17] | 0.77
Na (mmol per L) | 136 [134,137] | 136 [135,137] | 0.65
Initial Pain | 7 [5,8] | 7 [6,8] | 0.69
Appendicolith | 3 (16%) | 3 (43%) | 0.30
Appendix Diameter (mm) | 8 [7,11] | 9 [6,13] | 0.76
Liberalization and Fast-Tracking

• Cost-effectiveness (considering prospective data only)
  • Early failure rate of 27% and recurrence rate of 26%
  • $9,753 per patient for non-operative management
  • $9,755 for appendectomy

• Fast-Tracking
  • Emergency room evaluation, 1 dose of IV Abx followed by outpatient PO course
Take Home for Non-operative Management

• ~75% initial success rate
• ~25% recurrence rate
• Most recurrences within 1 year
• Appendicolith associated higher failure rate
• Currently, longer inpatient time
• Faster recovery
• Less pain
• Cost-effective
Management

Appendicitis

Non-perforated

Perforation

Early

Abscess of Phlegmon

• Bowel Rest
• Fluid Resuscitation
• Antibiotics
• Pain Control
• Surgical Consultation
Management of Complicated Appendicitis

• 3 choices
  • Appendectomy
  • Non-operative management with interval appendectomy
  • Non-operative management
Management of Perforated Appendicitis - NO ABSCESS

Table 2. Health Care Use After Early Appendectomy or Interval Appendectomy

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Early (n=64)</th>
<th>Interval (n=67)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Received central venous catheter, No. (%)</td>
<td>28 (44)</td>
<td>58 (87)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Discharged with central venous catheter, No. (%)</td>
<td>6 (9)</td>
<td>29 (43)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Underwent IR procedure, No. (%)</td>
<td>13 (21)</td>
<td>15 (23)</td>
<td>.77</td>
</tr>
<tr>
<td>Total antibiotic duration, mean (range), d</td>
<td>13 (3-30)</td>
<td>15 (6-33)</td>
<td>.10</td>
</tr>
<tr>
<td>Operative time, mean (range), min</td>
<td>113 (39-213)</td>
<td>112 (48-295)</td>
<td>.95</td>
</tr>
<tr>
<td>CT scans during study period, mean (range), No.</td>
<td>1.3 (0-5)</td>
<td>1.7 (0-6)</td>
<td>.06</td>
</tr>
<tr>
<td>Hospital length of stay, mean (range), d</td>
<td>9 (2.6-23.9)</td>
<td>11.2 (3.3-40)</td>
<td>.03</td>
</tr>
</tbody>
</table>

Table 3. Adverse Events After Early or Interval Appendectomy

<table>
<thead>
<tr>
<th>Event</th>
<th>Early (n=64)</th>
<th>Interval (n=67)</th>
<th>RR Associated With Interval Appendectomy (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any adverse event</td>
<td>19 (30)</td>
<td>57 (55)</td>
<td>1.88 (1.21-2.87)</td>
<td>.003</td>
</tr>
<tr>
<td>Intra-abdominal abscess</td>
<td>12 (19)</td>
<td>25 (37)</td>
<td>1.99 (1.10-3.62)</td>
<td>.02</td>
</tr>
<tr>
<td>Small bowel obstruction</td>
<td>0 (0)</td>
<td>7 (10.4)</td>
<td>.91</td>
<td></td>
</tr>
<tr>
<td>Wound infection</td>
<td>6 (9.4)</td>
<td>6 (9.3)</td>
<td>0.94 (0.32-2.76)</td>
<td>.91</td>
</tr>
<tr>
<td>Unplanned readmission</td>
<td>5 (8)</td>
<td>21 (31)</td>
<td>3.94 (1.99-9.84)</td>
<td>.01</td>
</tr>
<tr>
<td>CVL-related adverse event</td>
<td>1 (1.6)</td>
<td>4 (6.0)</td>
<td>0.88 (0.21-3.72)</td>
<td>.15</td>
</tr>
<tr>
<td>IR procedure-related adverse event</td>
<td>0 (0)</td>
<td>1 (1.5)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Recurrent appendicitis</td>
<td>0 (0)</td>
<td>6 (9)</td>
<td>.01</td>
<td></td>
</tr>
</tbody>
</table>
Management of Perforated Appendicitis-NO ABSCESS- Cost Analysis

<table>
<thead>
<tr>
<th>Table 3. Comparison of Costs by Study Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost category</strong></td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Anesthesiology</td>
</tr>
<tr>
<td>Cardiology</td>
</tr>
<tr>
<td>Emergency department</td>
</tr>
<tr>
<td>Laboratory</td>
</tr>
<tr>
<td>Medical/surgical supply</td>
</tr>
<tr>
<td>Operating room</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>Pharmacy</td>
</tr>
<tr>
<td>Pulmonary/respiratory</td>
</tr>
<tr>
<td>Radiology</td>
</tr>
<tr>
<td>Room</td>
</tr>
<tr>
<td>Total costs</td>
</tr>
</tbody>
</table>

Data are reported as median (range).
Management of Complicated Appendicitis-Abscess or Phlegmon

- Prospective Randomized Trial
- 20 patients in each arm

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Outcomes comparing initial operation and initial abscess drainage followed by interval appendectomy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial operation (n = 20)</td>
</tr>
<tr>
<td>Operation time (min)</td>
<td>62.1 ± 38.7</td>
</tr>
<tr>
<td>Total length of hospitalization (d)</td>
<td>6.5 ± 3.8</td>
</tr>
<tr>
<td>Recurrent abscess after initial treatment (%)</td>
<td>20%</td>
</tr>
<tr>
<td>Doses of narcotics</td>
<td>9.7 ± 4.0</td>
</tr>
<tr>
<td>Total health care visits</td>
<td>2.8 ± 1.1</td>
</tr>
<tr>
<td>No. of CT scans</td>
<td>1.5 ± 0.7</td>
</tr>
<tr>
<td>Time to goal intake (h)</td>
<td>74.8 ± 53.9</td>
</tr>
<tr>
<td>Total charges</td>
<td>$44,195 ± $19,384</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± SD, unless otherwise indicated.

* Time to regular diet after drain placement or evaluation by interventional radiology in the initial nonoperative group.

Initial laparoscopic appendectomy versus initial nonoperative management and interval appendectomy for perforated appendicitis with abscess: a prospective, randomized trial.

Role of Interval Appendectomy

- Systematic review
- 127 patients
- Ein study with fecalith analysis
Antibiotics For Appendicitis

• If no perforation, strong evidence that children should receive preoperative broad-spectrum antibiotics (Grade A).

• Broad-spectrum, single, or double agent therapy is as effective as and more cost-effective than triple agent therapy for the treatment of perforated appendicitis (Grade B).

• The length of administration of IV antibiotics for children with perforated appendicitis should be based on clinical criteria, such as fever, pain, return of bowel function, and WBC count (Grade B).

• In children with perforated appendicitis, a 5-day course of IV antibiotics is recommended. IV antibiotics are given initially, but completing the antibiotic course with oral antibiotics (total 7 days IV + oral) had similar results compared to a minimum 5-day course of IV antibiotics (Grade B).

• The duration of administration of broad-spectrum IV antibiotics for nonoperative management of perforated appendicitis should be based on clinical criteria (Grade D).
Doc, what would YOU do?

• Easy: Perforated appendicitis
  • Early: Appendectomy

• Abscess or Phlegmon: Non-op management without interval appendectomy***

• Uncomplicated appendicitis with features predicting failure (large fecalith, diameter > 1.2 cm): Appendectomy

• Hard:
  • The rest.........
Thank You

• Questions?